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VALUATION AND DEPRECIATION RELATED TO INCOME TAX

By Maurice R. Scharff, M. ASCE

POWER DIVISION

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PAPERS

VALUATION AND DEPRECIATION RELATED TO INCOME TAX

By Maurice R. Scharff,[1] M. ASCE

Synopsis

The importance of income tax considerations in comparing the economic feasibility of engineering projects and the effect of these taxes on valuation and depreciation of existing public utility plants is emphasized in this paper.

An example is cited to show the effect of income taxes on comparative annual costs of two types of power plants. Equations are presented to express the relation between value and income tax. In effect, the income tax is equivalent to an additional fixed charge on the investment.

To illustrate the application of the methods developed, a computation of service value and accrued depreciation is developed for a hypothetical manufactured gas company.

Introduction

Previous discussions of the valuation and depreciation of public utility properties[2] have suggested logical methods of determining these amounts by computations of present worth of reasonable earning power. A review of the solutions offered has led to the recognition that it is necessary to give specific effect to income taxes in such computations. To the same extent and in somewhat the same manner this consideration enters into engineering-economic comparisons of alternative projects. Logical procedures can be developed which will give full recognition to the influence of income taxes on these economic factors.

Engineering-Economic Comparisons

Before proceeding to the consideration of the valuation and depreciation of public utility property, the importance of income taxes in engineering-economic

Note.—Written comments are invited for publication; the last discussion should be submitted by October, 1951.

[1] Cons. Engr., New York, N. Y.

[2] "Valuation and Depreciation of Public Utility Property," by M. R. Scharff, *Transactions*, ASCE, Vol. 114, 1949, pp. 907–954.

comparisons can be illustrated by an example. It is assumed that a comparison is to be made between a hydroelectric plant with a transmission line and a steam-power plant as alternative methods of providing a capacity of 100,000 kw and supplying 450,000,000 kw-hr of energy per year. The cost per kilowatt of the hydroelectric plant and transmission line is assumed to be $500, and the cost per kilowatt for the steam plant is assumed to be $200. Assume further that the rate of return to be earned after income taxes is 6% and that the capital for either project will be provided in the ratio of 50% in bonds paying 3% and 50% in capital stock. The capital stock, then, must earn 9% after income taxes in order that the average return on capital may be 6%. Assume also that: (*a*) the operating expenses of the hydroelectric plant and transmission line can be taken at $4.00 per kw per year; (*b*) the fuel cost for the steam plant is $0.004 per kw-hr; and (*c*) the other production expenses of the steam plant are $6.00 per kw per year.

Then if depreciation is computed on the 6% sinking-fund basis for 80 years in the case of the hydroelectric plant and for 40 years in the case of the steam plant, the comparative annual costs exclusive of income tax will be as follows:

Type of plant	Hydro	Steam
Operating Expenses	$ 400,000	$2,400,000
Depreciation	29,000	129,000
Return	3,000,000	1,200,000
Total	$3,429,000	$3,729,000

A comparison on this basis would seem to indicate that the hydroelectric plant was more economical by $300,000 per year. However, if the resulting saving in income taxes from the customary application of straight-line depreciation rates for income tax purposes is neglected and if income taxes are determined on the basis of the foregoing returns, less bond interest only, it would theoretically be necessary to add to the annual cost $1,500,000 of income tax at an assumed 40% rate. This added sum is the amount that the owner of the hydroelectric plant would have to pay to earn a taxable income corresponding with a net income of $2,250,000 after deducting $750,000 bond interest. Similarly, the $600,000 income tax that the owner of the steam plant would have to pay in order to earn a taxable income corresponding with a net income of $900,000, after deducting $300,000 bond interest, must be added. The total cost, including income tax, on this basis would be $4,929,000 for the hydroelectric plant compared with $4,329,000 for the steam plant, indicating that, from the point of view of the rate-payer, the steam plant is more economical by a sum equal to $600,000 a year.

On the other hand, if the allowable total charge to the rate-payers were to be limited to the foregoing totals (plus income tax) and if income taxes were computed more realistically on the basis of the aforementioned sums of depreciation and return—less straight-line depreciation over 80 years and 40 years, respectively (neglecting salvage), and less bond interest—the resultant income taxes would be $1,102,700 for the hydroelectric plant and $352,700 for the steam plant. On this basis the total costs would be $4,531,700 and $4,081,700, respectively, indicating that the steam plant is more economical by $450,000 per year.

Valuation of Public Utility Property

The writer has suggested previously[3] a formula defining value as the present worth of the earning power of existing utility property at reasonable rates. This may be expressed algebraically as:

$$V_c = [E\,A_e - (O_c - O_e)]\,P_c \quad \ldots\ldots\ldots\ldots\ldots\ldots (1a)$$

or

$$V_c = \frac{E\,A_e - (O_c - O_e)}{A_c} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1b)$$

in which E is the cost of the most economical facilities; A_e is the annuity at reasonable rate of return (R) whose present worth for the capitalization period of the most economical facilities is 1; O_c is the operating expenses of existing facilities; O_e is the operating expenses of most economical facilities; P_c is the present worth at rate R of an annuity of 1 per year for the future capitalization period of the existing facilities $\left(\frac{1}{A_c}\right)$; and A_c is the annuity at rate R whose present worth for the future capitalization period of the existing facilities equals $1\left(\frac{1}{P_c}\right)$.

The formulation expressed by Eqs. 1 is incomplete in that it fails to give effect to the relation of income taxes to the valuation and depreciation of public utility property to which reference has been made previously. The total reasonable revenue corresponding with the economical cost of rendering the service must include income taxes necessary to earn the required return on the cost of the most economical facilities. The income taxes necessary to earn a corresponding return on the value of the existing facilities must be provided out of these reasonable revenues, in addition to operating expenses, depreciation, and return.

For any given situation in which capital structure, bond interest rate, and income tax rate are given, the income tax is equivalent, in fact, to a specific additional fixed charge on the investment. If the saving in income tax due to the use of straight-line depreciation for income tax purposes is neglected and if the income tax is based on return less bond interest, such additional fixed charge is equal—for a capitalization with $B\%$ bonds and $(1 - B)\%$ stock—to

$$t = \frac{I\,(R - B_i)}{1 - I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In Eq. 2, I is the income tax rate expressed as a percentage of net income after bond interest; R is the rate of return expressed as a percentage of total investment; B is the ratio of bonds to total capitalization; and i is the interest rate on bonds. For example, if I is 40%, R is 6%, B is 50%, and i is 3%, the income tax

[3] "Valuation and Depreciation of Public Utility Property," by M. R. Scharff, *Transactions*, ASCE, Vol. 114, 1949, p. 914.

TABLE 1.—Summary of Computation of Service Value and Accrued

Account No.	Designation	Cost of reproduction new of existing plant[a] (thousands of dollars)	Cost of most economical facilities to furnish service[a] (thousands of dollars)	Capitalization period for most economical facilities[b] (years)	Annuity factor at 6% for period in Col. 5 plus income tax ratio	Annuity plus income tax on cost of most economical facilities[c] (thousands of dollars)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
311	Land	2,500	2,500	Indefinite	0.08760	219.0
312	Structures and improvements	4,000	3,500	60	0.08947	313.1
313	Boiler plant equipment	900	1,000	35	0.09657	96.6
314	Other power equipment	300	400	50	0.09104	36.4
316	Coke ovens	2,000	1,800	35	0.09657	173.8
317	Producer gas equipment	400	400	38	0.09496	38.0
318	Water gas generating equipment	1,300	1,500	40	0.09406	141.1
321	Coal, coke, and ash handling equipment	2,200	2,200	55	0.09014	198.3
322	Gas reforming equipment	60	60	40	0.09406	5.6
323	Purification equipment	1,600	1,500	34	0.09720	145.8
324	Residual refining equipment	600	550	48	0.09150	50.3
325	Other production equipment	1,440	1,390	34	0.09720	135.1
	Total production plant	17,300	16,800			1,553.1
341	Land	500	500	Indefinite	0.08760	43.8
342	Structures and improvements	4,500	4,200	70	0.08863	372.2
	Total storage plant	5,000	4,700			416.0
361	Land	300	300	Indefinite	0.08760	26.3
362	Structures and improvements	900	800	60	0.08947	71.6
363	Mains	18,600	14,200	65	0.08899	1,263.7
364	Pumping and regulating equipment	1,000	800	35	0.09657	77.3
365	Services	6,800	6,200	48	0.09150	567.3
366.1	Meters	4,800	4,700	30	0.10025	471.2
366.2	House regulators	8	8	48	0.09150	.7
366.3	Meter installations	1,792	1,792	50	0.09104	163.1
	Total distribution plant	34,200	28,800			2,641.2
370	Land	300	300	Indefinite	0.08760	26.3
371	Structures and improvements	2,200	2,000	60	0.08947	178.9
372	Office furniture and equipment	500	500	20	0.11478	57.4
373	Transportation equipment	200	200	10	0.16347	32.7
374	Stores equipment	15	15	25	0.10583	1.6
375	Shop equipment	25	25	28	0.10219	2.6
376	Laboratory equipment	20	20	22	0.11065	2.2
377	Tools and work equipment	220	220	12	0.14688	32.3
379	Miscellaneous equipment	20	20	22	0.11065	2.2
	Total general plant	3,500	3,300			336.2
	Total plant in service	60,000	53,600			4,946.5

[a] Estimated. [b] Assumed same as for existing facilities except for account 363, for which total capitalization land excluded this value is 0.210. [c] With land excluded this value is 0.097. [d] With land excluded this value is

by Eq. 2 equals 3% of the investment. If I is 38% and the other factors are unchanged, the income tax is 2.76% of the investment.

On this basis the value of an existing property affected by obsolescence can be expressed algebraically, either in a form corresponding to Eq. 1*a*, the method of calculation used previously[4] which is:

$$V_e = \frac{[E\,(A_e + t) - (O_c - O_e)]}{1 + P_e\,t}\,P_e \ldots\ldots\ldots\ldots\ldots\ldots (3a)$$

[4] "Valuation and Depreciation of Public Utility Property," by M. R. Scharff, *Transactions*, ASCE, Vol. 114, 1949, p. 917.

DEPRECIATION FOR HYPOTHETICAL MANUFACTURED GAS COMPANY

Redistribution of Col. 7 (thousands of dollars)	Annual operating expense savings by most economical facilities[a] (thousands of dollars)	Amount available for capitalization,[d] Col. 8 − Col. 9 (thousands of dollars)	Future capitalization period for existing facilities (years)	Annuity factor at 6% for period in Col. 11 plus income tax ratio	Service value of existing facilities Col. 10 ÷ Col. 12 (thousands of dollars)	Accrued Depreciation	
						Col. 3 − Col. 13 (thousands of dollars)	Col. 14 ÷ Col. 3
(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
219.0	....	219.0	Indefinite	0.08760	2,500	....	....
333.6	20	313.6	45	0.09230	3,398	602	0.150
90.7	20	70.7	21	0.11260	628	272	0.302
29.1	10	19.1	39	0.09449	202	98	0.327
169.7	30	139.7	25	0.10583	1,320	680	0.340
38.0	....	38.0	26	0.10450	364	36	0.090
140.1	50	90.1	29	0.10118	890	410	0.315
196.4	2	194.4	42	0.09328	2,084	116	0.053
5.6	....	5.6	29	0.10118	55	5	0.083
137.0	30	107.0	21	0.11260	950	650	0.406
51.3	3	48.3	39	0.09449	511	89	0.148
136.1	5	131.1	29	0.10118	1,296	144	0.100
1,546.6	170	1,376.6			14,198	3,102	0.179[e]
43.8	....	43.8	Indefinite	0.08760	500	....	....
373.9	3	370.9	49	0.09126	4,064	436	0.097
417.7	3	414.7			4,564	436	0.087[f]
26.3	....	26.3	Indefinite	0.08760	300	....	....
72.5	2	70.5	43	0.09293	759	141	0.157
1,263.7	....	1,263.7	57	0.08985	14,065	4,535	0.244
79.3	12	67.3	28	0.10219	659	341	0.341
567.3	....	567.3	33	0.09787	5,796	1,004	0.148
471.2	....	471.2	17	0.12304	3,830	970	0.202
0.7	....	0.7	39	0.09449	7	1	0.125
163.1	....	163.1	31	0.09939	1,641	151	0.084
2,644.1	14	2,630.1			27,057	7,143	0.209[g]
26.3	....	26.3	Indefinite	0.08760	300	....	....
180.8	3	177.8	35	0.09657	1,841	359	0.163
57.4	....	57.4	12	0.14688	391	109	0.218
32.7	....	32.7	6	0.23096	142	58	0.290
1.6	....	1.6	16	0.12655	13	2	0.133
2.6	....	2.6	14	0.13518	19	6	0.240
2.2	....	2.2	12	0.14688	15	5	0.250
32.3	....	32.3	6	0.23096	140	80	0.364
2.2	....	2.2	12	0.14688	15	5	0.250
338.1	3	335.1			2,876	624	0.178[h]
4,946.5	190	4,756.5			48,695	11,305	0.188[i]

period of existing facilities is 80 years. [e] Col. 6 times Col. 4. [d] As service value of existing facilities. [e] With 0.211. [h] With land excluded this value is 0.195. [i] With land excluded this value is 0.200.

or, more simply, by the equivalent expression (compare with Eq. 1*b*):

$$V_c = \frac{E\,(A_e + t) - (O_c - O_e)}{A_c + t} \qquad (3b)$$

On the other hand, if the effect of straight-line depreciation on income tax is taken into account, and if L_e is defined as the service life and total capitalization period of the most economical facilities and if L_c is defined as the remaining life and future capitalization period of the existing facilities, then the ratio of income tax to value will differ in the two cases. For the most economical facilities, it

will be—

$$t_e = \frac{\left(A_e \frac{-1}{L_e} - B\,i\right) I}{1 - I} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4a)$$

and for the existing facilities—

$$t_c = \frac{\left(A_c - \frac{1}{L_c} - B\,i\right) I}{I - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4b)$$

As an example for $L_e = 40$ years with other constants the same as before, then $t_e = 1.764\%$ with a 40% income tax rate or 1.622% with a 38% income tax rate. Using t_e and t_c for these expressions, the value of an existing property affected by obsolescence can be expressed in a form analogous to Eq. 1*a*:

$$V_c = \frac{[E\,(A_e + t_e) - (O_c - O_e)]}{1 + P_c\ t_c} P_c \quad \ldots\ldots\ldots\ldots\ldots\ldots (5a)$$

or for greater ease in computation by the equivalent expression (compare Eq. 1*b*):

$$V_c = \frac{E\,(A_e + t_e) - (O_c - O_e)}{A_c + t_c} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5b)$$

As a matter of interest, the application of Eq. 3*b* (neglecting the reduction of income tax through use of straight-line depreciation for income tax purposes) to the example of the "Hypothetical Manufactured Gas Company,"[5] has been calculated using a capitalization of 50% bonds paying 3% interest and 50% stock and having an income tax rate of 38%. The result of the calculation is shown in Table 1. It will be noted that consideration of "theoretical" income tax results in a total service value of the existing facilities of $48,695,000 compared with $46,969,600 as previously cited. Furthermore the ratio of accrued depreciation to the cost of reproduction new of the existing plant is 18.8% if land is included and 20.0% if land is excluded. Ignoring income taxes, the corresponding ratio of accrued depreciation to cost of reproduction new was 21.717% if land was included and 23.104% if land was excluded.

A similar computation, giving consideration to "realistic" income tax, by the application of Eq. 5*b*, has also been made, which yielded a total service value of existing facilities equal to $48,857,000 compared to $46,969,600 computed without considering income taxes. The comparable ratio of accrued depreciation to cost of reproduction new of existing plant is 18.6% if land is included and 19.8% if land is excluded, instead of 21.717% and 23.104%, respectively, without giving effect to income taxes.

In all of the computations referred to herein, the "unadjusted compound interest" method of calculation has been used for simplicity in calculation and presentation, without taking into account the effect of probable dispersion of retirements.

[5] "Valuation and Depreciation of Public Utility Property," by M. R. Scharff, *Transactions*, ASCE, Vol. 114, 1949, Table 1, pp. 920–921.

Property taxes and insurance are generally related in some manner to the value of the property. Nevertheless, the methods of fixing insurance values and tax assessments are of such uncertain relation to value in the sense of present worth of earning power at reasonable rates that it may well be preferable to consider these elements of cost as expenses determined independently and not related to value on the basis of service value. On the other hand, if these items were considered to be related directly to the service value that is being sought, it would be necessary to take them into account in exactly the same manner as has been suggested for income tax. The algebraic formulations previously presented would be extended by adding a term for the ratio of such insurance and property taxes to value.

The subject of this paper has received little attention in the past, and others who are interested may wish to extend the consideration of the subject by criticism and futher analysis of the problem.

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